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Review of the Office of Research and Development's Land Disposal Research Program

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The Committee made the following technical recommendations based on its review of the current Land Disposal Research Program:

- The research program should identify the changes in wastes likely to be land disposed in the future. Pollutant characterization projects should, in particular, be conducted for large volume wastes and leachates, municipal solid waste and leachates, and incinerator ashes and leachates.

- EPA should pursue field-scale, long-term research to obtain a fuller technical understanding of the performance of cover and liner systems.

- The emphasis on land disposal closure and post-closure operations and monitoring should be increased because many land disposal facilities recently have been closed and other will be closed.

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D C 20460

SAB-EEC-88-003

October 9, 1987

OFFICE OF
THE ADMINISTRATOR

Honorable Lee M. Thomas
Administrator
U. S. Environmental Protection Agency
401 M Street, S. W.
Washington, D. C. 20460

Dear Mr. Thomas:

The Science Advisory Board's (SAB) Environmental Engineering Committee has completed its review of the Office of Research and Development's (ORD) Land Disposal Research Program and is pleased to transmit its final report to you. The review occurred at a public meeting on June 4-5 at EPA's Andrew W. Breidenbach Laboratory in Cincinnati and included participants from the Hazardous Waste Environmental Research Laboratory and ORD Headquarters. The report was approved by the SAB Executive Committee on October 8th.

Among the major conclusions and recommendations reached by the Committee are the following:

o Although not widely acknowledged, land disposal must continue to be an integral part of the nation's waste management strategy. Other waste management options exist and will be used, but land disposal has a continuing, inevitable, and important waste management role for EPA and for the nation.

o EPA needs a strong and continuing land disposal research program to address important issues, including: (a) the land disposal of ash from the incineration of hazardous and municipal solid wastes, very small quantity generator wastes, residues produced by best demonstrated available technology (BDAT) treatment of hazardous wastes, and large volume wastes; (b) the proper design of Subtitle D facilities, including municipal landfills and industrial non-hazardous waste landfills and surface impoundments; and (c) appropriate methods for the closure and post-closure care of hazardous and non-hazardous landfills, surface impoundments and waste piles.

o There is a need to evaluate and understand the long-term performance of what are now considered environmentally sound land disposal practices and the associated monitoring methods to assure that these practices are environmentally sound over many decades.

o The Committee's review of the Land Disposal Research Program indicates that these needs are not recognized by the Congress and the EPA, and that EPA does not have a waste management strategy that defines the continuing role of land disposal. Unless this is corrected, EPA and the nation will lack the scientific and technical knowledge necessary to the ongoing development of scientifically sound land disposal guidance and regulations.

o Congress and the EPA should provide adequate support for the Land Disposal Research Program so that it can continue to provide land disposal data and information and develop a mechanism so that individual shifts in Agency-wide priorities do not leave it devoid of an important capability in land disposal.

The Committee appreciates the opportunity to evaluate this important research program and acknowledges the full cooperation it has received from EPA staff in conducting the review. We request that the Agency formally respond to the scientific advice provided in the attached report.

Sincerely,

Norton Nelson
Chairman
Executive Committee

Raymond C. Loehr
Raymond Loehr
Chairman
Environmental Engineering Committee

SAB-EEC-88-003

REVIEW OF
THE OFFICE OF RESEARCH AND DEVELOPMENT'S
LAND DISPOSAL RESEARCH PROGRAM

REPORT OF THE

ENVIRONMENTAL ENGINEERING COMMITTEE

OF THE

SCIENCE ADVISORY BOARD

U.S. ENVIRONMNENTAL PROTECTION AGENCY

October, 1987

NOTICE

This report has been written as part of the activities of the Science Advisory Board, a public advisory group providing extramural scientific information and advice to the Administrator and other officials of the Environmental Protection Agency. The Board is structured to provide a balanced expert assessment of scientific matters related to problems facing the Agency. This report has not been reviewed for approval by the Agency and, hence, the contents of this report do not necessarily represent the views and policies of the Environmental Protection Agency, nor of other agencies in the Executive Branch of the Federal government, nor does mention of trade names or commercial products constitute endorsement of recommendation for use.

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I. EXECUTIVE SUMMARY

This report presents an evaluation of the Land Disposal Research Program (LDRP) of the Environmental Protection Agency's (EPA's) Office of Research and Development (ORD) by the Environmental Engineering Committee of EPA's Science Advisory Board. The LDRP has been an ongoing ORD research activity whose objective is "to improve the technology and capability for containing hazardous and solid waste on or beneath the land surface."[1] The technical support needs of EPA's Office of Solid Waste (OSW) in implementing the Resource Conservation and Recovery Act (RCRA) have largely driven the focus of the LDRP in recent years.

Although not widely acknowledged, land disposal must continue to be an integral part of the nation's waste management strategy. Other waste management options exist and will be used, but land disposal has a continuing, inevitable, and important waste management role for EPA and for the nation. A variety of wastes will continue to be land disposed in the future. For some wastes, land disposal is the only viable alternative. The LDRP can help to assure that such disposal will be protective of human health and the environment.

EPA needs a strong and continuing land disposal research program to address important issues, including: (a) the land disposal of ash from the incineration of hazardous and municipal solid wastes, very small quantity generator wastes, residues produced by best demonstrated available technology (BDAT) treatment of hazardous wastes, and large volume wastes; (b) the proper design of Subtitle D facilities, including municipal landfills and industrial non-hazardous waste landfills and surface impoundments; and (c) appropriate methods for the closure and post-closure care of hazardous and non-hazardous landfills, surface impoundments and waste piles.

Another need that can be met by the LDRP is to evaluate and understand the long-term performance of what are now considered environmentally sound land disposal practices and the associated monitoring methods to assure that these practices are environmentally sound over many decades. In spite of the research conducted to date, it is very difficult to predict that improved land disposal, such as "secure" landfills, will be protective of human health and the environment for the long-term future. Without such an understanding, the nation will not have a permanent solution to the proper management of the above wastes and may continue to find itself with the need to clean up many more waste disposal sites.

The Committee's review of the LDRP indicates that these needs are not recognized by the Congress and the EPA, and that EPA does not have a waste management strategy that defines the continuing role of land disposal. Unless this is corrected, EPA and the nation will lack the scientific and technical knowledge necessary to the ongoing development of scientifically sound land disposal guidance and regulations.

This situation appears to have occurred because, as with almost all EPA research programs, the LDRP is driven by immediate and legitimate program office needs for information to support Congressional mandates and court deadlines to develop regulations. As a result of changing program office direction,

the research focus has shifted during the past decade. In the 1970's, the LDRP emphasized municipal solid wastes in response to the needs of the Solid Waste Act. With the passage of the Resource Conservation and Recovery Act (RCRA) in 1976, the focus began to change to the control of hazardous wastes. In recent years, the LDRP has evaluated whether hazardous waste land disposal methods are protective of human health and the environment. With the current (RCRA) emphasis on BDAT, and alternative technologies to land disposal (needs that resulted from the requirements in the 1984 RCRA Amendments), the perceived need for hazardous waste land disposal research efforts has declined. These funding reductions, if continued, will cripple the program's ability to meet the Agency's future technical requirements in regard to the use of environmentally sound land disposal methods.

Research conducted to date by the program has responded to the Agency's short-term priorities for regulation and guidance. The need to satisfy OSW's direct and relatively immediate needs, however, combined with the constraints upon ORD research funding, strongly limit the program's continued productivity. These constraints also make the LDRP vulnerable to swings in perceived needs by OSW and the EPA Research Committees. Decisions to shift resources to focus on the immediate regulatory and program office needs can be defended individually. The cumulative result of those individual decisions, however, is that EPA is left with a LDRP that does not meet its overall needs.

The Committee believes that a land disposal research program is an major research effort for EPA, that it is important to maintain a critical mass of of qualified people within the program, and that current LDRP staffing and resource levels are below those needed to maintain the vigor in the program that EPA needs. The Congress and EPA should: recognize that a land disposal research program must be an integral part of EPA research and development activities, and develop a mechanism within EPA so that individual shifts in research emphasis do not leave EPA devoid of an important capability.

Based upon its review of the current LDRP, the Committee's specific technical recommendations include:

- o The research program should identify the changes in wastes likely to be land disposed in the future. Pollutant characterization projects should, in particular, be conducted for large volume wastes and leachates, municipal solid waste and leachates, and incinerator ashes and leachates.

- o EPA should pursue field-scale, long-term research to obtain a fuller technical understanding of the performance of cover and liner systems.

- o The emphasis on land disposal closure and post-closure operations and monitoring should be increased because many land disposal facilities recently have been closed and others will be closed.

- o Research on land disposal designs that facilitate repairs should be increased.

- o Monitoring data collected at RCRA-permitted facilities should be used fully to evaluate various containment designs.

- o The LDRP should continue to seek opportunities for cooperative efforts in which the funds and experience of non-governmental organizations can be used to extend its own program.

- o The LDRP should take the lead role in establishing a formal information transfer network, at least within EPA, to make accessible information being developed on all aspects of land disposal.

- ° Existing technology transfer activities should be continued. This information is important to the regulated community and to permit writers in the states and regions. In particular, the land disposal "Technical Resource Documents" (TRDs) should be updated and renumbered sequentially to facilitate their use.

The Committee supports and commends ORD for its work on expert systems, as applied to land disposal issues. The Agency, however, should be prepared to fully support not only the development of such systems, but also testing, distribution, maintenance and updating, education and training. Most importantly, there should be adequate testing of the system and the decisions it may potentially support. The systems must not only be user-friendly, but also "novice fool-proof." ORD should assess the resources needed to fully support these systems. If the Agency is unable to make such a commitment, it should consider not developing such systems.

II. INTRODUCTION

At the request of the Deputy Administrator and the Assistant Administrator for the Office of Research and Development, the Science Advisory Board (SAB) Executive Committee agreed to conduct a review of ORD's Land Disposal Research Program. This review is part of a continuing series of SAB research program reviews intended to provide independent scientific advice on ongoing research and to identify any needed modifications to the content or direction of research programs. More specifically, the objective of this review was to assess whether the Land Disposal Research Program was well-conceived and coordinated, responsive to the needs of the Agency, scientifically current, appropriately anticipating emerging issues and adequately funded.

The Executive Committee assigned the review to the SAB Environmental Engineering Committee (EEC). In the past several years, the EEC has reviewed a number of issues related to land disposal, hazardous waste, ground water and research program needs for each of these areas. To conduct the review, the Committee formed a Subcommittee of land disposal experts (Appendix A).

In April 1987, ORD provided a briefing document which formed the basis of the review.[1] On June 4-5, 1987, the Subcommittee conducted the review at EPA's Andrew W. Breidenbach Laboratory in Cincinnati. EPA participants included Dr. Thomas Hauser, Director of the Hazardous Waste Environmental Research

Laboratory (HWERL), and HWERL and ORD Headquarters staff. At the end of the review, the Subcommittee discussed its initial findings with the staff and prepared this report. The findings and report were discussed by the full Environmental Engineering Committee and subsequently reviewed and approved by the SAB Executive Committee on October 8, 1987.

The Committee wishes to express its appreciation for the efforts of all of the ORD Land Disposal Research Program staff. Their documents and discussions were informative, professional and extremely helpful to the reviewers.

III. REVIEW OF THE ORD LAND DISPOSAL RESEARCH PROGRAM

A. GENERAL COMMENTS

This program conducts research in order "to improve the technology and capability for containing hazardous and solid wastes, on or beneath the land surface."[1] A further objective is to prevent the release of pollutants from a waste to the surrounding air, land, and water media. The technical support needs of the EPA's Office of Solid Waste (OSW) in implementing the Resource Conservation and Recovery Act (RCRA) have largely driven the focus of the LDRP in recent years. Support of Superfund activities is a growing part of the program. The research is applicable to hazardous (RCRA Subtitle C) and non-hazardous wastes (Subtitle D) landfills, surface impoundments, and waste piles. Not included in this review was research related to land treatment, deep well injection, underground storage tanks and waste storage in mines.

1. Although the Committee supports the research conducted to date by the LDRP, the Committee is most concerned about the absence of a waste management strategy* that also defines the continuing role of land disposal. Without such a broader strategy, it is difficult, if not impossible, for the Agency to construct (and set priorities within) coherent, pro-active program plans, including research programs.

As discussed below, a waste management strategy should recognize that land disposal has an inevitable and important role. Therefore, a strong and continuing land disposal research program must be an important and major activity of the EPA. The Committee's review of the LDRP indicates that this is not recognized by the Congress or the Agency. Unless this is corrected, EPA and the nation will lack the scientific and technical knowledge necessary for the ongoing development of scientifically sound land disposal guidance and regulations.

2. This situation appears to have occurred because, as with almost all EPA research programs, the LDRP is driven by the immediate and legitimate, program office needs for information to support Congressional mandates and court deadlines to develop required regulations. Changes in program office requirements over the years have resulted in redirections of the research effort. In the 1970's for example, the LDRP emphasized municipal solid wastes in response to the needs promulgated to comply with the Solid Waste Act. With the passage of the Resource Conservation and Recovery Act in 1976, the focus began to change to the control of hazardous wastes. In recent years, the

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*In this report, strategy means an articulation of a concept or goal and the types of activities necessary to implement the concept. A program, or program plan, is an articulation of the details of the specific projects, timetables, and funding necessary to implement a strategy or a component of a strategy.

LDRP has evaluated whether hazardous waste land disposal methods are protective of human health and the environment. With the current (RCRA) emphasis on determining BDAT, and alternative technologies to land disposal (needs that resulted from the requirements in the 1984 RCRA Amendments), the need perceived by the Congress and the EPA for land disposal research efforts has declined. As a result, the LDRP has sustained substantial funding reductions which, if continued, will cripple the program's ability to meet future technical requirements for decision making.

The Committee believes that the LDRP has responded to the Agency's short-term priorities, particularly those priorities associated with promulgation of hazardous waste land disposal disposal regulations by the Office of Solid Waste. The need to satisfy the OSW's direct and relatively immediate needs, however, combined with the limitations of ORD's research funding, strongly limits the program's continued productivity. These constraints also make the LDRP vunerable to swings in perceived needs by OSW and the EPA Research Committees.

The decisions to shift resources to focus on the immediate regulatory and program office needs can be defended individually. The cumulative result of the individual decisions, however, is that EPA is left with a LDRP that does not meet its overall needs.

3. Land disposal will continue to be a very important waste management activity. There are only three major ultimate disposal locations: air, land and water. Although other waste management options exist and will be used, land disposal has a continuing, inevitable, and important waste management role for EPA and for the nation. A variety of wastes will continue to be land disposed in the future, and EPA's land disposal research can help assure that such disposal will be protective of human health and the environment. Environmentally sound land disposal practices will be needed even more in the future for municipal solid wastes, household hazardous wastes, and very small quantity generator hazardous wastes; residues resulting from BDAT treatment of hazardous wastes; high volume wastes such as fly ash, bottom ash, and mining wastes; CERCLA remediation wastes; incinerator residues; demolition wastes; and contained wastes with no other technically feasible or economic disposal alternative. In addition, technology is needed to retrofit existing land disposal facilities, and for future facilities. EPA needs a strong, pro-active land disposal research program to address these issues.

Another need that can be met by a strong LDRP is evaluating and understanding the long-term performance of what are now considered environmentally sound land disposal practices and the associated monitoring methods to assure that they are environmentally sound over many decades. In spite of the research conducted to date, it remains very difficult to predict that improved land disposal practices, such as "secure" landfills, will protect human health and the environment over the long-term. Without such an understanding, the nation will not have a permanent solution to the proper management of the above wastes and may continue to find itself with the need to clean up waste disposal sites.

4. The Committee believes that: (a) a land disposal research program is an important and major research program for EPA, (b) it is important to maintain a critical mass of qualified people within the program, and (c) the current LDRP staffing and resources are below the levels needed to maintain the vigor in the program that EPA and the nation need. Therefore, the Congress and the EPA should recognize that a LDRP must be an integral part of research and development activities, and should develop a mechanism so that individual shifts in research emphasis do not leave the Agency devoid of an important capability.

Based on its review of the current LDRP, the Committee's specific technical recommendations include:

- o The research program should, in particular, identify the changes in wastes likely to be land disposed in the future. Pollutant characterization projects should be conducted for large volume wastes and leachates, municipal solid waste and leachates, and incinerator ashes and leachates.

- o EPA should pursue field-scale, long-term research to obtain a fuller technical understanding of the performance of cover and liner systems.

- o The emphasis on land disposal closure and post-closure operations and monitoring should be increased because many land disposal facilities recently have closed, and others will close.

- o Research on land disposal designs that facilitate repairs should be increased.

- o Monitoring data collected at RCRA-permitted facilities should be used fully to evaluate various containment designs.

- o The LDRP should continue to seek opportunities for cooperative efforts in which the funds and experience of non-governmental organizations can be used to extend its own program.

- o The LDRP should take the lead role in establishing a formal information transfer network, at least within EPA, to make accessible information being developed on all aspects of land disposal.

- o Existing technology transfer activities should be continued. This information is important to the regulated community and to permit writers in the states and regions. In particular, the land disposal "Technical Resource Documents" (TRDs) should be updated and renumbered sequentially to facilitate their use.

The Committee supports and commends ORD for its work on expert systems, as applied to land disposal issues. The Agency, however, must be prepared to fully support not only the development of such systems, but also testing, distribution, maintenance and updating, education and training. Most importantly, there should be adequate testing of the system and the decisions it may potentially support.

The systems must be user-friendly and "novice fool-proof." ORD should assess the resources needed to fully support these systems. If the Agency is unable to make such a commitment, it should consider not developing such systems.

5. Over the years, the LDRP has attempted to leverage its funds by working with manufacturers of liners, leachate and gas collection and treatment devices, and equipment; and with contractors who construct land disposal systems. The Committee commends these efforts. Experience has shown that care in the construction of landfills and other disposal systems, and care in selecting liners and other system components, is extremely important to long-term integrity and environmentally sound performance. This interaction has resulted in the development of better evaluation procedures and consensus standards for flexible membrane liners, and the involvment of industrial trade organizations and the ASTM (formerly American Society on Testing and Materials) in approaches to develop better analytical and evaluative methods for defining the performance of land disposal components and units. Such cooperative efforts represent a very sound method to obtain private sector involvment in the development and evaluation of improved processes and systems. The LDRP should continue such activities as an important means of leveraging its resources and expanding this interaction so that it becomes a more integral part of the LDRP.

6. Both the Hazardous and Solid Waste Act (HSWA) Amendments and the Superfund Amendments and Reauthorization Act (SARA) authorize EPA to develop new regulatory initiatives for Subtitle D landfills. Open dumps have been, or are being, replaced with sanitary landfills. The growing body of knowledge on the behavior of materials in the sub-surface environments, however, suggests that the current sanitary landfill technology may not adequately protect human health and the environment.

HWERL personnel developed much of the available data on Subtitle D landfills, but there has been a hiatus of almost ten years in the Subtitle D program. The Committee recommends reinstating and revitalizing this effort in response to contemporary concerns. Much of the land disposal research conducted over the past five to ten years in support of Subtitle C regulations is relevant to Subtitle D facilities, but it would need to be reframed within the Subtitle D context.

7. Information about pollution characterization, containment systems, waste management operations, closure and post-closure management, corrective action and performance evaluations is available from many sources. A more formal interaction of the LDRP with other research and development efforts is desirable.

The Committee recommends that the LDRP take a lead role in establishing a more formal network among government agencies, industry, trade associations and academia for the collection and sharing of information on such land disposal related issues identified in #4 above. Examples of the programs and issues that could be included in this network include: (a) DOD/DOE/EPA joint remedial action studies; (b) the Environmental Monitoring and Systems Laboratory (EMSL) toxicity characteristic testing and monitoring methods development programs; (c) the Water Environmental Research Laboratory (WERL) land disposal program for sludges; (d) the Superfund Innovative Technologies Evaluation (SITE) program activities; and (e) the land disposal portion of EPA grants programs and academic research.

8. Although not currently part of the LDRP, the Committee recommends that a research effort should be initiated to provide the technical background to support the development of regulations for long-term storage of wastes in salt domes, salt caverns, and mines.

HSWA prohibits the placement of liquid hazardous waste in salt domes, salt beds, underground mines or caves pending: (1) a determination by EPA that such placement is protective of human health and the environment; (2) promulgation of performance and permitting standards; and (3) issuance of a permit for the facility concerned. All other hazardous wastes are also prohibited from placement in salt domes, salt beds, underground mines or caves until a permit has been issued. Since a permit cannot be issued until standards have been promulgated, and standards are based on protecting human health and the environment, the three conditions on placement of liquids effectively apply to placement of all hazardous wastes.

In enacting the prohibition, Congress did not make a determination that salt formations, mines or caves are unsuitable for long-term storage of hazardous wastes. In fact, Congress specifically allowed the nuclear Waste Isolation Pilot Project conducted by the Department of Energy in New Mexico to continue. The Congressional prohibition merely judged that salt formations, mines and caves are sufficiently different from other forms of land emplacement as to require specifically tailored regulations and permits.

The experience at Herfa-Neurode in West Germany, one of the most highly regarded hazardous waste storage facilities in the world, and results in the United States, where salt domes are used for storing the strategic petroleum reserves, suggest that sites of this kind could be valuable adjuncts to these forms of sub-surface disposal. Data need to be collected, however, to support the development and analysis of alternative regulatory strategies.

B. SPECIFIC COMMENTS

1. Pollutant Characterization Program

This research area, one of the larger components of the LDRP, is aimed at characterizing both the waste materials placed in landfills (and to a lesser extent in impoundments and waste piles) and the leachates and gases from such systems. The research projects, those presently funded as well as those planned, and the commendable work done in the past, are on-target in addressing the present needs of regulatory development and enforcement.

Several important emerging issues that ORD and OSW should consider in setting future directions of this program include:

- o Characterization methods and a data base are needed for large volume wastes (often largely destined for monofills) such as utility fly and bottom ashes and mining wastes.

- o The data base on toxic components in leachate releases from municipal solid waste landfills needs to be improved. The 1985 SAB evaluation of the EPA Ground Water Research Program concluded that ground water contamination from such landfills can rival that of landfills receiving wastes defined as hazardous.[2] Funding planned for Subtitle D research in FY 1988 should be continued.

- o A more substantial data base on leachates from incinerator residues derived from hazardous wastes, municipal solid wastes, and POTW sludges—all wastes likely to be land disposed in the future--needs to be developed.

- o ORD and OSW should consider the need for developing data on the performance of BDAT residues in land disposal options. These residues can have different characteristics than those currently being disposed of in such facilities. It appears that the identified OSW FY'88 and FY'89 research needs have not recognized this need. There are minimal data on the characteristics of BDAT residues and on the compatability of such residues with proposed land disposal methods.

Stronger links should be established with other parts of ORD that are conducting related research, such as EMSL, WERL, and Atmospheric Environmental Research Laboratory.

2. Containment Program - Liners and Covers

The containment program has been appropriately targeted to develop basic test methods for, and engineering data on, flexible membrane liners (FMLs), covers and, more recently, geotextiles and geonets. The program has taken a leadership position in these developments by leveraging resources to encourage cooperative work with industry. The work to develop predictive techniques for chemical resistance of FMLs is important to eventually providing methodologies for non-test screening of materials. The work to develop data has been generally limited to bench scale laboratory studies. To provide the demonstrated engineering data required to support permitting decisions, high priority should be given to continuing and expanding full-scale testing of FML systems. Particular emphasis should be placed on useful life calculations using predictive techniques, short-term laboratory data, and actual long-term field experience.

Geonets and geotextiles are newer materials. The program has encouraged the development of test standards for these materials. Obtaining long-term physical and chemical property data under actual use conditions is a key to their ultimate acceptance by the permit writer and public. Again, field tests are required.

Soil/clay liner studies should be conducted at a much larger scale than previously. Scale-up from bench-scale lysimeters may not be satisfactory, and construction techniques present one of the key variables in the use of this group of liner materials.

Constructability is a key factor in the use of all types of liners. Of particular importance are liner support, liner/soil interface, and the ability to achieve uniformity, as well as quality assurance/quality control (QA/QC). This area is the basis for developing sound predictive models on which technology-based regulations can be written and defended. It is distressing that essentially all large-scale work in the entire area of FML systems and soil liners reportedly will be terminated. If this occurs, the Agency may be in a technically indefensible position in the 1990's.

The LDRP has recognized the important role covers play in long-term containment of Subtitle C and Subtitle D wastes. The cover is a critical element in long-term performance of any closed waste facility -- landfill impoundment, waste pile, or mining/large volume waste site. It can also be a key element in closure/remedial measures at facilities (whether Subtitle C, Subtitle D, or CERCLA sites).

The LDRP has focused on both soil and geotextile/geomembrane use for cover systems, emphasizing two aspects of the problem - infiltration control and erosion control. The LDRP is also addressing many of the critical problems in cover design and construction. There is considerable overlap with liner design and construction and validation of the HELP model. However, the recent severe cut-back in containment system research will leave significant gaps in the program. The most critical gaps are in the areas of construction procedures, quality control, and long-term performance of the cover systems. Long-term containment is an important goal and, therefore, these critical questions must be answered.

Past research at HWERL, and elsewhere, has indicated significant differences between laboratory and field determination of many hydrologic parameters. There is an indication that many hydrogeologic properties are scale-dependent. Large-scale experiments and field verification studies are needed to resolve the issue. Studies need to identify which properties may be scale-dependent or, at best, which properties may have a significant difference between laboratory values and those determined in the field or by large-scale experiments. Attempts should also be made to correlate, if possible, the laboratory and field results.

Construction properties of natural earth and man-made materials should be focused on the containment facility. For example, existing laboratory tests on compaction and density have only limited transferability to actual constructed properties. Attempts should also be made to correlate laboratory geotechnical properties of natural and man-made materials to field-measured values and long-term performance of these materials.

3. Waste Management Operations and Closure of Landfills

Given that there are thousands of municipal solid waste and hazardous waste landfills in the U.S. today, and that land disposal will continue in some form into the foreseeable future, waste management operations at landfills and closure of landfills are areas of long-term importance. Waste management operations that include in situ volume reduction and resource recovery currently receive little attention in the LDRP. Compaction as a method of volume reduction has probably progressed to an acceptable level; however, the potential of in situ degradation for volume or toxicity reduction has received little attention. The single project in the LDRP program on anaerobic dechlorination of hazardous wastes, while a good project, inadequately addresses this important area. (The Agency's restrictions against land disposal of chlorinated hazardous wastes makes this project less relevant.) A systems approach should be taken in developing both aerobic and anaerobic biodegradation processes for volume or toxicity reduction in both municipal and hazardous waste landfills. The accumulation of waste at one site, at considerable cost in time and energy, represents the first step in process development that may make biodegradation more feasible. The physical process of containment in a landfill concentrates wastes in structures that might be further engineered into bioreactors. If further developed and operated, landfill bioreactors could represent an important first step in resource recovery.

The high state-of-the-art of metals recovery during pre-landfill operations suggests that in situ metals recovery would not be cost-effective. However, as has been demonstrated in a few cities, methane recovery from municipal landfills is a feasible and cost-effective resource recovery process. Further development in this area and wider application of methane recovery might significantly reduce the total costs of solid waste handling.

Since current and upcoming regulations de-emphasize landfilling as the preferred method of municipal and hazardous waste disposal, landfill closure will become a major activity in the near-term. Hence, closure procedures and post-closure monitoring will soon become areas of great regulatory and public concern. The LDRP should reflect this shift in emphasis and significantly increase activities in the closure and post-closure operations and monitoring areas. In addition, the current emphasis on incineration for volume reduction and disposal of municipal and hazardous wastes will result in a shift in the type of solid waste (to ash) landfilled in the future. Since ash has physical-chemical properties that differ greatly from the mix of solid wastes currently landfilled, this change in "product mix" should be recognized in the future research agenda. In particular, the importance of metals in the leachate from ash landfills may require different approaches in permitting, design, construction, operation, closure, and monitoring of landfills in the future. The treatment of hazardous waste with BDAT technolgies will also change the types of wastes that will be land disposed in the future. A program to address the probable change in types of materials landfilled is recommended.

4. Corrective Action

Landfills will eventually leak. Unresolved questions that have been, and should continue to be, addressed by the LDRP include:

o What leaks, other than water? (leachate and air emissions characterizations)

o Where do leaks occur in an engineered subsurface containment system?

o How can leaks be prevented?

o When leaks occur, how can they be repaired?

o How can subsurface containment systems be designed to facilitate repairs?

The last two questions drive the LDRP's corrective action (i.e. repair) program. The one project on field repair of synthetic landfill and lagoon liners is nearing completion. No funding has been made available to support further efforts in this area. The Committee believes that research on designs that facilitate repairs deserves funding.

5. Performance Evaluation

The LDRP's performance evaluation program is aimed at collecting, analyzing, and interpreting field data from operating containment systems. The work provides the experiential background needed to develop answers to all of the above mentioned questions. The work is also needed to document the technical feasibility and effectiveness of regulatory requirements, many of which were promulgated without any direct field experience.

The efforts designated as "Performance Evaluation" have concentrated largely on expert systems, statistical tools and predictive models. The essential link between development of interpretive systems and field applications, however, has not been fully established. Ideally, the interpretive systems should provide insight into data that should be collected in the field; and the field data should provide insights into directions for improvement of the interpretive systems. The process is then iterated to the benefit of the overall program.

HWERL is to be commended for pioneering efforts in the application of expert systems to assist permit writers in evaluating permit applications. There is a danger, however, that such systems will be used as the sole or major basis to make decisions, an application for which they were never intended. They can help and guide permit writers, but must never be allowed to substitute for them. Field applications are essential to guide improvements of the expert systems, but should be closely monitored to assure against misuse (see additional discussion in section 6, below).

Only a short-term knowledge base about performance of land disposal facilities exists. This knowledge was obtained over the past few decades. It is not extensive and has focused on older, less environmentally sound land disposal technologies, such as unlined landfills. Little field experience is available on the performance of the newer designs for secure landfills, surface impoundments, and other land disposal facilities. To adequately protect human health and the environment, it is imperative that EPA have a research effort to evaluate and understand the long-term performance of land disposal facilities. Performance evaluation data are critically needed to assure the long-term security of land disposed wastes; to develop proper monitoring methods and procedures; to ascertain suitable closure and post-closure procedures; and to identify methods to maintain system integrity and reliability. Without such long term performance information, EPA will have a poor technical data base on which to establish and refine technology-based regulations.

Monitoring data are collected at all permitted land disposal facilities to comply with RCRA regulations. These data, supplemented with information on the design and construction of the facilities and on site-specific hydrogeology, are a rich source for tests of the LDRP's interpretive models and for improving the long-term performance of land disposal units. Data from remediated CERCLA sites and from DOE and DOD sites are another potential source.

6. Technology Transfer

This component of the LDRP includes the preparation of a series of Technical Resource Documents (TRDs), responding to inquiries from state and EPA personnel, summarizing the results of ongoing projects, conducting symposia and training seminars, and developing and disseminating expert systems to aid EPA regional and state regulatory authorities. Approximately 15 percent of program resources are devoted to this effort.

The Technical Resource Documents are directed at meeting needs imposed by RCRA and HSWA. Fourteen documents have been issued to date. They exist in various states: EPA is revising them, incorporating them into a CERCLA handbook, superseding them, transferring them to another laboratory, and cancelling planned revisions. The Committee recommends that, since the TRDs are widely used in evaluating designs for land disposal facilities, emphasis be placed on completing revisions of the relevant TRDs, such as the "Guidelines for Land Disposal of Solid Wastes." In addition, the Committee recommends that ORD, OSW, and/or CERI (ORD's Center for Environmental Research Information) assign a single series identification to these documents.

The LDRP staff provides permitting and other technical assistance to the EPA regions and to states. This is an important link between the knowledge obtained and its practical application and should be continued.

HWERL has done a commendable job in sponsoring an annual hazardous waste symposium during the past thirteen years. This symposium is a nationally recognized event that has attracted an increasing number of attendees (>1200 in 1986). A seminar for permit writers is held twice a year. They should continue.

Expert systems can be a very useful technology transfer method to assure that the best knowledge is used for decision making. For land disposal activities, well constructed and implemented expert systems can facilitate sound permit preparation, permit reviews and evaluations, technology screening decisions and initial design decisions. The Committee admires the development of expert systems to aid permit writers in evaluating FML test data. It anticipates that the development and use of such systems by the Agency would expand.

EPA as a whole must recognize, however, that development and use of expert systems requires a continuing commitment, including continuing support for new systems, user support, education of users, product maintenance and updating, and preparation of training and demonstration packages. Expert systems should not be developed and placed in field use unless the Agency is ready and able to commit significant resources to support the user community in the early years of their application. There should be a rigorous quality assurance of a system and on the user decisions during initial use. Personnel should be available to respond to questions, train the user community, and trouble-shoot system problems. A user "certification" program should be given high priority.

The LDRP should critically assess the current and long-term needs to develop and support the use of expert systems for the above stated purposes. ORD and the program offices should provide such support or should consider not developing such systems. The absence of long-term support will lead to frustration, inefficient use of resources, and faulty decisions by users.

APPENDIX A

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APPENDIX B

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